

we are incapable of supplying our own wants. Major Cardew, after considering and summing up the relative advantages of the two systems, gives his verdict against continuous current and feels "confident in prophesying the successful application of the polyphase system to the working of full-scale railways."

PRIZE-SUBJECTS IN APPLIED SCIENCE.

THE programme of subjects for which prizes will be awarded by the Société industrielle de Mulhouse next year has been issued, and copies can be obtained upon application to the secretary of the Society. In general chemistry, medals will be awarded for the best memoirs or works on the theory of the manufacture of alizarin reds; the synthesis of the colouring matters of cochineal; theoretical and practical study of the carmine of cochineal; study of the colouring matter of cotton; the composition of aniline blacks; physical and chemical modifications which occur when cotton fibre is transformed into oxycellulose; action of chlorine and its oxygen compounds upon wool; constitution of colouring matters employed in linen fabrics; synthesis of a natural colouring matter used in indries; and theory of the natural formation of an organic substance and preparation of the substance by synthesis.

In connection with dyeing, medals will be awarded for the best works presented on the following subjects:—A new mordant which admits of practical use; metallic solutions which give up their bases to textile fibres, and the conditions in which they are most effective; iron mordants and the part they play in dyeing according to their condition of oxidation and hydration; an aniline black which will not deteriorate in the presence of other colours or affect these colours, especially those of albumin; a soluble black for dyeing which will resist the action of light and soap as much as aniline black; a light blue cheap enough to be used to dye woollens and not affected by boiling or by light; a blue similar to ultramarine which can be fixed upon cotton by a chemical process; a pure yellow which behaves like alizarin as regards its dyeing properties; a lake-red; a purple; a colouring matter to supersede logwood in its various applications; an assistant especially applicable to wool, capable of being cleared by simple washing, and composed of substances other than tin salts, hydrosulphites, sulphites, and bisulphites; new method of fixing aniline colours; a means of making colours resist the action of soap or of prolonged boiling; a means of producing the sheen of gold and silver upon materials by metallic powders; a manual containing tables showing the densities of as many inorganic and organic compounds as possible, in the crystallised state and in cold saturated solution; the synthesis of a substance having the essential properties of Senegal gum; a substance to supersede egg-white in the dyeing of linen; a colourless blood albumin which can be used instead of egg-white; a manual on the analysis of compounds employed in fabric printing and in dyeing; an indelible ink for marking cotton and similar materials; a practical method of removing grease spots from materials; a memoir on the use of resins in bleaching cotton fibre; a memoir on the bleaching and dyeing of various kinds of cotton; also memoirs dealing similarly with wool and silk; use of hydrogen peroxide for bleaching; improvements in the bleaching of wool and silk; and manuals on the bleaching of cotton, wool, silk, hemp and other fibres.

In connection with fabric printing, medals are offered for an alloy or other substance which has both the elasticity and durability of steel and also the property of not causing any chemical action in the presence of acid colours and colours containing certain metallic salts; a new cylinder machine capable of printing at least eight colours at once; and an application of electricity to bleaching, dyeing or fabric printing.

Among the prize subjects in mechanical arts are:—A means of recording by a graphical method the work done by steam engines in a given period (ordinary indicator diagrams do not fulfil the conditions); memoir on the spinning of combed wool; on the force required to start spinning machines; a motor for driving machines used in printing fabrics.

In electricity medals will be awarded for an electric motor the power and driving rate of which can be easily varied; a memoir on the comparative cost of electricity and gas for lighting a town having a population of at least 30,000; and comparative costs of electricity, gas, acetylene and water-gas for lighting an industrial establishment.

Money prizes as well as medals are awarded for some of the subjects, and all the competitions are open to every one, irrespective of nationality. The memoirs, designs or models submitted for the awards should be sent to the president of the Société industrielle de Mulhouse before February 15, 1902.

PROGRESS OF CIVIL ENGINEERING.¹

IN response to a request of the Institution of Civil Engineers, Tredgold gave this ever memorable definition of civil engineering in 1828:

"Civil engineering is the art of directing the great sources of power in Nature for the use and convenience of man; being that practical application of the most important principles of natural philosophy which has, in a considerable degree, realised the anticipations of Bacon, and changed the aspect and state of affairs in the whole world."

After a brief sketch of the objects of civil engineering, he added:—"The real extent to which it may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors."

A more concise and comprehensive definition of a great truth can hardly be conceived. From a physical and intellectual standpoint, a nobler aim for the exercise of the mental powers cannot be imagined than the direction of the great sources of power in Nature for the use and convenience of man. Psychology deals with mind alone, physics considers the nature and the laws of matter, but civil engineering treats of the intelligent direction of the laws governing matter so as to produce effects which will reduce to a minimum the time and physical labour required to supply all the demands of the body of man and leave more opportunity for the exercise of the mental and spiritual faculties. Philosophy, physics and civil engineering must work hand in hand. The philosopher must imagine, the physicist prove by experiment and mathematical computation, and the engineer apply to practice the laws of matter. Each must keep himself informed of the progress made by the others and must aid them by suggestions as to the lines on which research needs to be carried forward. The civil engineer, in attempting to solve some problem of construction, finds that he needs a material which shall possess a certain quality which he cannot discover that any natural product possesses. He calls the chemist to his aid, and he, from a study of the combinations of existing forms of matter which most nearly approach the desired ideal, reasons that some special combination of elements will entirely fulfil the conditions, and he experiments to find whether such combination can be made. Sometimes he is successful in his first attempt and sometimes not. But, whatever the result, he has added to his knowledge of the laws of combinations and has furnished to the philosopher fresh data for his generalisations and to the engineer a new material for his use.

As the knowledge of the nature of steel and the precise methods in which it can be manufactured have progressed, the engineer has gradually come to know just what he wants and how it can be produced, and, in his specifications, requires that the particular material of this class which he desires shall be of a certain chemical composition and also possess certain characteristics. The same is the case with almost every material which enters into the construction of engineering works of the present day. Matter in its original state is rarely used. Its chemical condition must be transformed before the engineer can utilise it with any confidence. That almost any desired transformation can be effected was not realised until late in last century. Starting with the atom, the ultimate particle of matter so far comprehended by us, the chemist found that several different kinds of atoms could be identified, and that these would combine in certain ways according to laws which could be formulated. But in the application of these laws and the tabulation of the results gaps were found to exist which could not be filled without the supposition that other elements existed than those already known. The existence of such elemental substances was confirmed by the revelations of the

¹ Abridged from an address delivered at the annual meeting of the American Society of Civil Engineers, June 25, by the president, Mr. J. J. R. Croes.

spectrum analysis, and, later on, several of such elements have been actually identified by the use of the electric current in creating vibrations in the ether. The limit is probably not reached yet, but as each new element is discovered its affinities are sought by the chemist, its sensibility to various forms of vibratory motion are investigated by the dynamist, as we may term the physicist who is seeking the laws of either heat or light or electricity, and then it is the function of the civil engineer to study how it can best be applied to the use and convenience of man. For, ever since the beginning of the nineteenth century, the evidence has been cumulative that matter in motion accounts for all physical phenomena, that motion produces energy, that energy is never wasted but is simply transformed, and that it manifests itself to the senses of man in various modes which are appreciable by the several organs of sense.

What our senses recognise as chemical affinity, heat, light and electricity are simply conditions of matter induced by vibrations or quivers or waves or strains, whatever we may call them, of different kinds and at different velocities. Neither matter nor motion can be originated by man, but, by a careful study of the sequence of events, control can be acquired of their modes of interaction, and natural phenomena can be artificially reproduced and other phenomena be produced. The intelligent application and direction of such means of control is the function of the civil engineer.

In considering the means of directing the great sources of power, the psychological element must not be forgotten. A mere intellectual application of the laws discovered by physical research is not enough to make a civil engineer. Breadth of view, the faculty of analysing what has been done so as to discover how and why some enterprises have been successful and others have not, and the ability to forecast the future, are essential. These qualities are largely natural, but may be cultivated to a great extent by study and experience. That there has been a wonderful advance in this direction during the nineteenth century is shown by the great number of civil engineers who hold positions of prominence in the management and control of large enterprises which require the exercise of faculties which cannot be acquired in any other way than by experience in the designing, construction and management of engineering works.

A prominent factor in causing this advance in engineering science which has occurred simultaneously on the Continent of Europe, in Great Britain and in America, has been the collaboration of men of science. Early in the century it became evident that the multiplication of lines of research demanded a differentiation of the labour of their prosecution and a close cooperation of the workers in any special line, and various associations of specialists were formed to promote various branches of scientific research. By the middle of the century it had become apparent that civil engineering was not the prosecution of a speciality, but was the coordination and direction of the work of all specialities in science and its applications.

Recognising, then, that progress is a law of Nature, the acceleration of progress is the aim of civil engineering. It strives to simulate the results of the slow processes of Nature by causing the sources of power to act rapidly in any desired direction. Appreciating, too, the fact that there is constant progress and that what now seems admirably adapted to our needs may in a short time require to be superseded by improved structures and processes, the tendency of the time is toward the production of works which will have a definite term of life, rather than towards the construction of everlasting monuments. We see that in the old nations, where the effort to build for eternity was made, time has outstripped the intent of the builders and what is antiquated is useless, and we see the same thing in our own streets to-day. The idea of building a monumental structure which will hand one's name down to future ages is a fascinating one, but it is simply a survival of the engineering of the Pharaohs.

The most thorough exemplar of the condition of civil engineering at the beginning of the twentieth century is the modern office building in a great city. One hundred years ago, the man of enterprise who resided fifty miles from a large city and wished to consult an engineer regarding a project for a new canal, arose before daylight, struck a spark from his flint and steel, which falling on a scrap of tinder was blown by him into flame and from that a tallow dip was lighted. In the same primitive manner, the wood fire was kindled on the kitchen hearth and his breakfast was cooked in a pot and kettle suspended from the iron crane in the fireplace. Entering the

cumbrous stage coach, hung on leather springs, which passed his door, he was driven over muddy roads, crossing the narrow streams on wooden trestle bridges and the navigable rivers on a ferry boat, the paddle wheels of which were turned by a mule on a treadmill. At last he was landed in the city, where he walked through dirty streets paved with cobble stones until he reached his destination, a plain three-story brick building founded on sand, with a damp cellar and a cesspool in the back yard. Entering a dark hall he climbed wooden staircase and was ushered into a neat room, rag-carpeted, warmed by a wood fire on the open hearth and lighted by a sperm oil lamp with one wick, for it was dark by this time.

To-day, his grandson, living at the old homestead, while comfortably eating his breakfast, which has been cooked over a gas range, reads in his morning paper that the high dam of the irrigation reservoir in Arizona, in which he is interested, sprang a leak the day before, and he telegraphs to his engineer in the city that he will meet him at his office at noon. Then, striking a match, he lights the lamp of his automobile, which is fed by petroleum brought 200 miles underground in pipes from the wells, rolls over macadamised roads to the railroad station, where he enters a luxuriously appointed train, by which he is carried above all highways, through tunnels, under rivers, or across them on long-span steel bridges, and in an hour is deposited in the heart of the city, where he has his choice of proceeding to his destination through clean and asphalt-paved streets in electric surface cars at nine miles an hour, elevated steam cars at twelve miles an hour, or through well-lighted and ventilated tunnels at fifteen miles an hour. Reaching the spot his grandfather had visited, he finds there a huge and highly decorated building, twenty or more stories high. Founded on the primeval rock, far below the surface of the natural ground, the superjacent strata of compressible material having been penetrated by caissons of sheet metal sunk by the use of air, compressed by powerful pumps driven by steam or electricity generated at a power station half a mile or more away, and these caissons filled with a manufactured rock such as the ordinary processes of Nature would require millions of years to produce, there is erected a cage of steel, the composition of which has been specified, and the form and mode of construction of which have been so computed that the force of the elements cannot overthrow the structure or even cause it to sway perceptibly. The meshes of this mighty cage are filled with products of the earth, the mine and the forest, transformed so as to be strong and light and incombustible, and all interwoven with pipes and wires, each in its proper place and noted on the plans. In one set of these pipes there is pure water, which has been collected from a mountain area of igneous geological formation, depopulated and free from swamps, on which a record of the daily rainfall is kept, and in which impounding reservoirs have been constructed by masonry dams across its valleys. From these reservoirs, the water, after filtration through clean sand, is conveyed thirty or forty miles through steel or masonry conduits to covered reservoirs, whence it is drawn as needed through cast-iron pipes to the building where it is to be used, and there distributed to all parts of it, chilled nearly to the freezing point through one system of pipes or heated nearly to the boiling point through another system. Another set of pipes carries steam which, passing through radiators, keeps the temperature of the air throughout the building at the proper standard for comfort. Sanitary conveniences are provided everywhere, and all wastes are consumed within the building by the surplus heat generated, leaving only ashes to be removed. Wires convey electric currents to all points, so that the occupant of a room, sitting at his desk, can by the touch of a button ventilate his apartment, illuminate it, call a messenger, be kept informed of every fluctuation in the markets, converse with anybody who is not "busy" within forty miles of where he sits and if entirely "up to date" can require his autograph and portrait to be reproduced before his eyes for identification. He dictates his correspondence and his memoranda, and "takes his pen in hand" only to sign his name. He need not leave his seat except to consult the photograph hanging on his wall, which shows to him the latest condition of the mine, the railroad, the arid lands irrigated, the swamps reclaimed, the bridge in progress, the steamship, the water-works, the tunnel or the railroad, the dam, the filter or the sewage works, the town, the machine, the power plant or the manufacturing establishment in which he is most interested.

Entering the brilliantly lighted hallway of this building, the

air of which is kept in circulation by the plunging up and down of half a dozen elevators, the visitor is lifted at a speed of 500 feet a minute, past floor after floor, crowded with the offices of financiers, managers and promoters of traffic and of trade, lawyers, chemists, contractors, manufacturers, to the headquarters of the controlling genius of the whole organism, the civil engineer. For he it is to whom all the members of this microcosm must apply for aid and advice in the successful operation of their respective occupations. It is not his to mechanically transform elements into matter, or matter into other forms, or to show how energy may be produced, but to direct the application of energy to the various forms of matter, original or produced, in such way as to bring about the most satisfactory results in the most speedy and economical manner.

He has grown with the growth of the nineteenth century, and is, so far as the relations between man and matter are concerned, its most striking product. And so, while the definition given in the "American Edition of the Encyclopædia," which appeared at the beginning of the century, that "Civil engineers are a denomination which comprises an order or profession of persons highly respectable for their talents and scientific attainments and eminently useful under this appellation," is still true, it is hardly probable that the compiler of the Twentieth Century Encyclopædia will be content to let it stand without further explanation.

But the end is not yet : there are still many problems of Nature unsolved. The experience of every day shows that there are sources of power not yet fully developed and we cannot but say with the great poet :

"I doubt not through the ages one increasing purpose runs,
And the thoughts of men are widened with the process of the suns."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

A GOOD estimate of the character of the work of a College or University can be obtained from the investigations carried on by its staff and students. The following statement of research work done in the laboratories of the McGill College, Montreal, last session, published in the Annual Calendar of the College and University for the session 1901-1902, furnishes excellent evidence of sound instruction and scientific activity :—The effect of cold on the physical properties of iron and steel ; the influence of bending on the torsional strength of metals ; the properties of iron and steel as affected by annealing at moderate temperatures ; experiments on frictional losses in $1\frac{1}{2}$ -inch pipes and bends under varying velocities of flow ; experiments on the determination of the "Miner's Inch" ; the separation and concentration of chromite, blonde, nickeliferous pyrrhotite and certain other minerals by combined gravimetric and magnetic methods ; the crushing and sizing of rocks by means of different types of apparatus ; the treatment of Nova Scotia mispickel concentrates by cyanide, bromocyanide and chlorination methods ; conditions affecting the wave form of alternators ; and the effect of change of wave form in alternators on induction and synchronous motors : induction motors used as frequency changers.

THE Massachusetts Institute of Technology has lately introduced the degree of Doctor of Philosophy to supersede the former degree of Doctor of Science. The following statement of the requirements for the new degree is of interest as showing the tendency of technical education in the United States :—“The degree of Doctor of Philosophy certifies to high attainments of a grade which qualifies the recipient as a scientific investigator and teacher. The course of study leading to this degree is mainly one of experiment and research, accompanied by such other theoretical subjects as may be useful adjuncts to the main scheme of work. The candidate must pursue his studies and researches under the direction and oversight of the Faculty for at least two school years, furnishing from time to time such evidences of progress as the Faculty may require. His attendance must be continuous, except in cases of absence previously approved by the Faculty for the purpose of conducting researches and investigations in the field. He must present a thesis embracing the results of an extended original investigation, and must pass such final examinations as the Faculty may require.”

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SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, August 19.—M. Fouqué in the chair.—The chairman announced the death of two members of the Academy, Admiral de Jonquieres and Baron de Nordenstiöld, and added a short account of their life-work.—The relations of psoriasis with neurasthenia : treatment by injections of orchitin, by M. F. Bouffé. Psoriasis is a trophonevrosis having its seat in the nervous centres and especially in the great sympathetic. It presents a great analogy with neurasthenia in its origin ; in both diseases there is constantly a diminution in nervous activity, characterised by a fall in the urographic line of phosphoric acid. The treatment of both should consist in the invigoration without stimulation of the nervous system by injections of orchitin, the average dose being from 10 to 12 c.c. three times a week.—On a problem of d'Alembert, by M. F. Siacci.—On a particular critical point of the solution of the equations of elasticity, in the case where the forces on the boundaries are given, by MM. Eugène and François Cosserat.—On the general principles of mechanisms, by M. G. Koenigs.—On the absolute value of the potential in isolated nets of conductors having a capacity, by M. Ch. Eug. Guye.—Researches on the mechanism of etherification in plants, by MM. E. Charabot and A. Hébert. Etherification in plants is produced by the direct action of the acid upon the alcohol, the action being favoured by a particular substance playing the part of a dehydrating agent, the latter being a diastase the dehydrating action of which is exercised in a chlorophyll medium.—Littoral deposits and movements of the soil during the secondary era in the Quercy and western Rouergue strata, by M. Armand Thevenin.—On the origins of the source of the Loue, by M. André Berthelot. Through the accident of a fire at an absinthe factory and the consequent liberation of a large quantity of absinthe, it became evident that the Loue represents a subterranean arm of the Doubs.—Observations of M. Berthelot on the preceding communication.—Influence of colour upon the production of the sexes, by M. C. Flammarion. A study of the effect of light of various colours upon the development of silk-worms.

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